

Innovative Product Design In EV Charging Connectors: Leveraging Topology And Shape Optimization

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Abstract

Problem Description:

During the assembly of electric vehicle (EV) power plugs, the plastic contact holder is prone to warping, which can result in functional failures such as inadequate sealing. This deformation compromises both the structural integrity and the overall performance of the component. While initial design modifications—such as the addition of localized reinforcing ribs—offered partial improvement, they proved insufficient for reliably mitigating the issue. To develop a more robust solution, mathematical optimization techniques, including both shape and topology optimization, were employed. These methods enable targeted, geometry-based reinforcement driven by objective performance criteria, reducing reliance on heuristic or experience-based design decisions.

Results:

The optimization process led to a substantial reduction in structural deformation of the contact holder. Shape optimization alone reduced the maximum deflection by approximately 60% compared to the original design. Subsequent application of topology optimization further decreased the deflection, achieving a total reduction of up to 75%. By integrating the results of both shape and topology optimization with domain-specific engineering insights, a redesigned contact holder was developed, exhibiting only 10% of the initial maximum deflection. As a side result, the study explored the use of the p-norm as an objective function to minimize von Mises stresses, which is crucial for improving fatigue performance.

Conclusions:

The shape optimization of the contact holder using COMSOL Multiphysics® software led to stiffer designs with less deformation. The use of the p-norm as an objective function proved effective in minimizing von Mises stresses, thereby enhancing the fatigue performance of the component. The symbiosis between optimization techniques and engineering knowledge shows very promising results in achieving more reliable and durable designs.

Reference

COMSOL Application ID:71731, Design Optimization of a Beam
COMSOL Application ID:75281, Shape Optimization of a Wrench
COMSOL Application ID:69891, Bracket - Topology Optimization

Figures used in the abstract

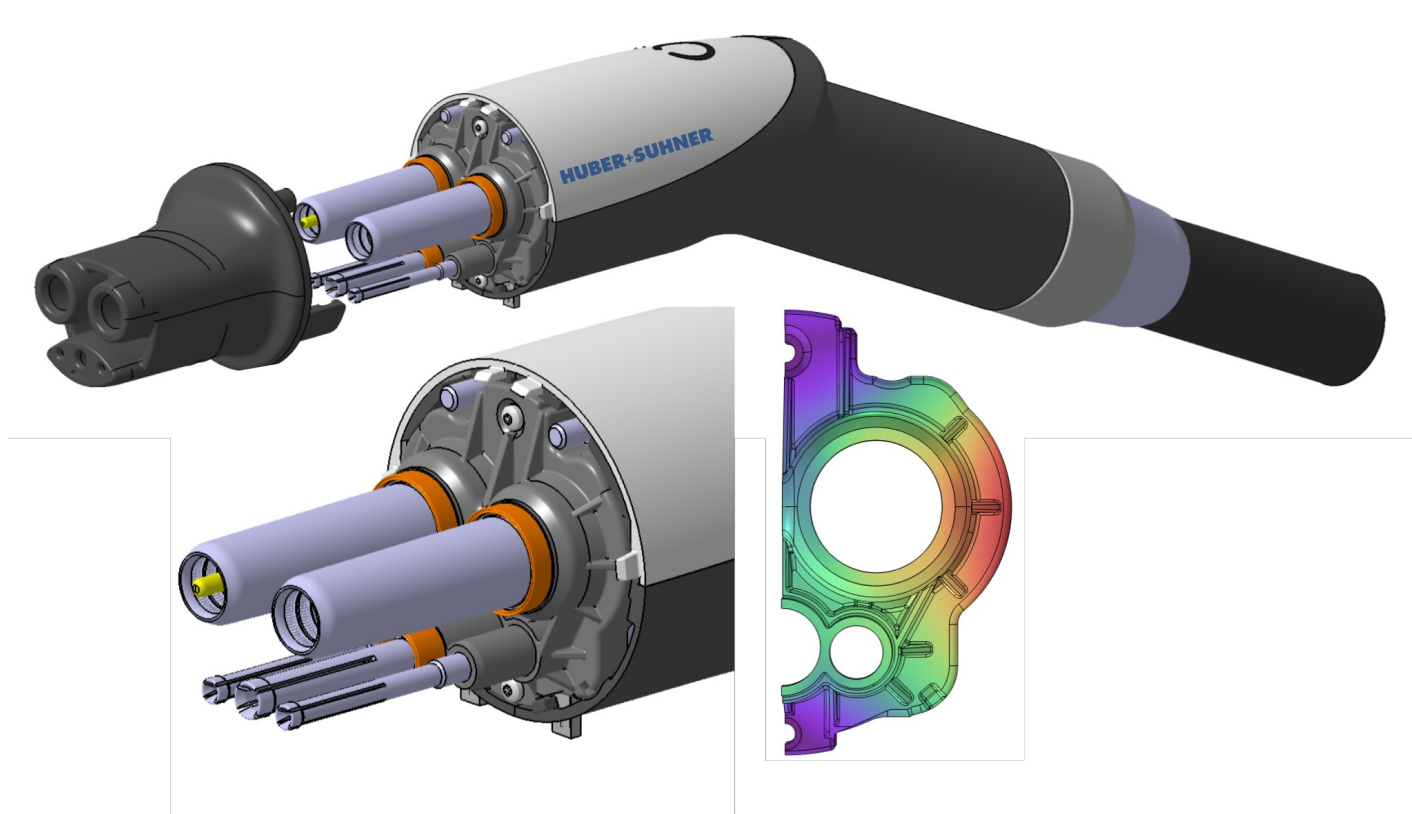


Figure 1 : Huber+Suhner NACS Charging Solution, top = assembly; bottom left = contact holder; bottom right = displacement magnitude

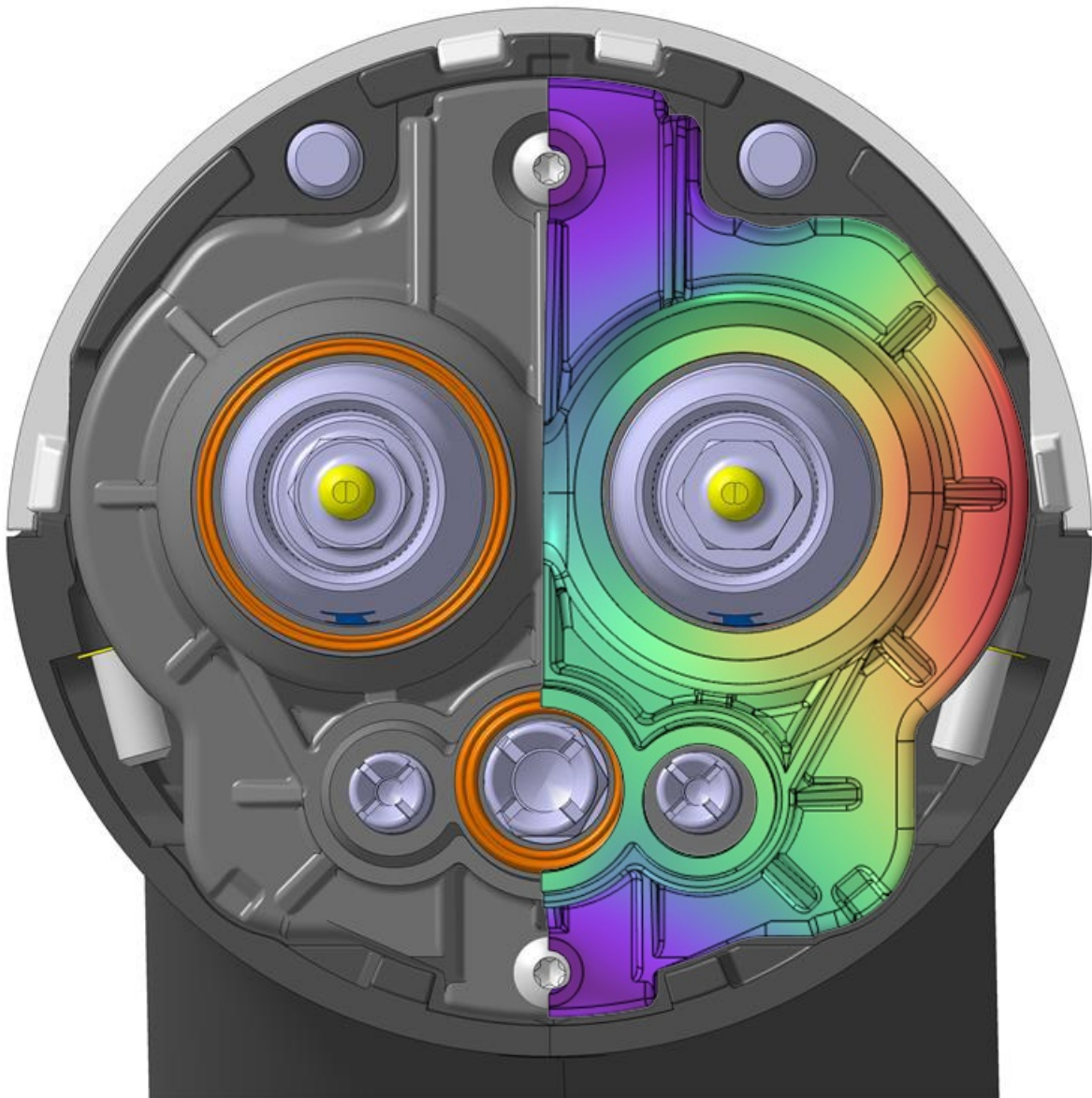


Figure 2 : Superimposed front view illustrating the alignment between CAD geometry and simulation results for the NACS charging solution